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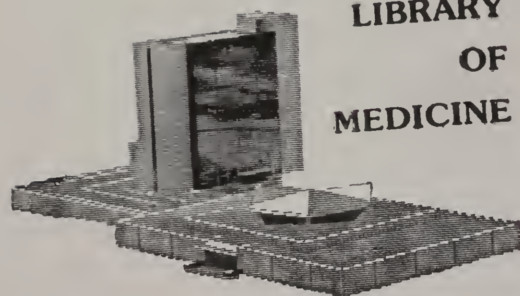

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INTERACTIVE TECHNOLOGY

by

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FOREWORD

The Lister Hill National Center for Biomedical Communications at the National Library of Medicine, in keeping with its long-standing commitment to develop and support innovative methods for training health care professionals, conducts research and development in applying computer, audiovisual, and multimedia technologies to health professions education. The Educational Technology Branch (ETB) focuses on interactive technology--the delivery of health sciences education through the combined use of microcomputer technology and optical disc-based images. The ETB also operates The Learning Center for Interactive Technology (TLC), a "hands-on" laboratory where visiting health sciences educators and researchers can explore the nature and application of interactive technology. TLC staff members provide tutorials in equipment set-up and use, in software utilization, and in design alternatives for the development of interactive courseware.

This series of TLC monographs is intended to capture the essence of these tutorials, thereby creating a set of "hands-on" publications which will guide the reader into the new world of interactive educational technology.

Michael J. Ackerman, Ph.D.
Chief, Educational Technology Branch

PREFACE

Publications concerning the application of technology to higher education and to professional education are plentiful. Technological devices suitable for instructional use are everywhere available. Yet, lasting innovations in technology-based teaching remain relatively uncommon.

Historically, one reason for this incongruity may be that educators and educational technologists too readily assumed that simply putting new technology to use would largely solve teaching problems in any discipline or setting. We now know better.

The instructional technology that now commands our attention, microcomputers and interactive video systems, is more complex and more powerful than earlier technologies. Its successful use will require extensive technical knowledge, rigorous attention to the principles of instructional design, careful planning and, perhaps, a bit of luck.

This monograph was developed as a service to the health sciences community and is intended as an introduction to interactive technology. Thus it was written to provide a brief overview rather than a detailed analysis of the field. It is offered with the hope that it will promote interest in applying interactive technology to health professions education and with the expectation that it will be followed by other publications that address specific problems in that undertaking.

ORGANIZATION REFERENCES AND ACKNOWLEDGEMENTS

Interactive technology product development is a widespread enterprise in which many commercial firms are engaged. Some of these firms and some product names are mentioned in this monograph; many others, obviously, are not. The use of a firm or product name does not in any way constitute an endorsement of that firm or product. The following list is provided merely to identify terms known to be trademarks held by particular firms.

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INTRODUCTION

New Technologies

That a communication technology can be used to transform education is an old and largely unproven idea. That computers can be used to transform education is a newer idea that also remains largely unproven. Still, optimism that a technological revolution in education is imminent continues to grow. It is largely rooted in an assemblage of technological tools and concepts that is widely called **Interactive Technology**. The key instrumental ingredients of interactive technology are microcomputers, optical disc systems, input and display devices, and software programs for authoring and delivering instructional programs. The key conceptual ingredients that underlie instructional program development are the consolidation of information resources on disc media, multimedia presentation, the individualization of instructional delivery, and, most importantly, interactivity and adaptivity in lesson design.

Existing computer-based programs, most on videodisc and many in the health sciences, illustrate well the technical and learning potential of interactive technology. They also suggest that the growing optimism regarding technology's future role in education may be justified.

Optical Discs

Although a computer is a necessary component for advanced interactive courseware development and delivery, the technical and functional variations that interactive systems can assume are better seen by looking at other components, especially the optical disc system. The term "optical disc" is useful because it excludes electrical capacitance videodiscs, which now are all but nonexistent in the United States, but includes two different analog laser videodisc systems, several digital technology formats that belong to the "compact disc" family, various "write once" systems, and an assortment of newly introduced "erasable" or "rewritable" systems. It is not completely inclusive, however, because interactive programs that use large capacity magnetic hard disks as a storage medium are being developed.

Report Contents

This report examines interactive technology systems and their use in education, especially health professions

education. It is intended to provide a general picture of their capabilities, their applications history and their present status. The first chapter provides a general overview of optical disc technology and describes the distinctive systems mentioned above. It also discusses authoring tools and integrated systems. The second chapter presents a brief history of organizational involvement in interactive technology development and concludes with a brief look at its current status. Chapter three describes a number of interactive programs in somewhat greater detail and examines the particular functions that they serve in educational settings. The final chapter examines some of the research that has been done to assess the adoption and effectiveness of interactive technology in education and to identify factors that appear to result in improved outcomes.

I. OPTICAL DISC SYSTEMS: AN OVERVIEW

Analog vs. Digital Disc

Optical disc technology includes a growing assortment of devices and systems with a wide range of capabilities and features. Basically, there are two distinctive optical disc media "families:" the standard laser videodisc and the compact disc. Also, there are two fundamentally different electronics technologies: analog and digital. As it happens, these two distinctions are essentially equivalent; all videodisc players are analog devices and all compact disc players or drives are digital devices. There are also two principal application sectors: consumer and industrial or educational; however consumer systems will not be discussed here.

This chapter begins with a discussion of analog videodisc formats and follows that with descriptions of several digital, optical disc systems that belong to the "compact disc" family, and of various "write once" and "erasable" systems. Authoring tools and videodisc interactivity "levels" are also discussed briefly. The intent is not to describe these systems in great engineering detail but simply to provide a general overview of optical disc technology and the products which employ it.

Optical Laser Videodiscs

All optical videodisc systems employ a laser beam to read information encoded on the disc. There are, however, two formats. In the **reflective** format, light is reflected off the surface of the disc whereas with the **transmissive** format light is beamed through a transparent disc.

Reflective format videodiscs are by far the most widely used of the two, and some of the well known brands include Pioneer, Sony, Philips and Hitachi. The tradename **LaserVision** is often used to identify the format.

The standard reflective optical disc is twelve inches in diameter, although there is also an eight inch version. A twelve inch constant angular velocity (CAV) disc, which rotates at 1800 revolutions per minute, provides 30 minutes of linear play or 54,000 still frames per side. An "extended play" option allows one hour of linear play

or 108,000 still frames per side. This is achieved by using a variable rotation rate feature--from 1800 to 600 rpm--which gives the disc a constant linear velocity (CLV). Many late model players can play both CAV and CLV discs; however, functions such as random access, still-frame and slow motion are generally not possible in the CLV mode.

Because nothing comes in contact with the disc during play, and also because of the disc's protective coating, no wear occurs and the useful life of the disc is virtually infinite.

The only transmissive format player currently on the market is the McDonnell Douglas Electronics Company's **LaserFilm** system which was introduced in 1986. In contrast to LaserVision technology, which involves computer-activated etching of pits onto a shiny, hard disc, the LaserFilm system employs a photographic process in which the video information is placed on a transparent film disc as a sequence of dots. This process provides a disc capacity of 32,400 still frames or 18 minutes of motion video. But while the photographic process makes disc mastering less costly, this format is little used in education.

Videodisc Interaction Characteristics

Much of the instructional value that videodisc technology affords derives from its extremely flexible presentation and interaction capabilities. In addition to providing normal video footage, still images, random-access, freeze-frame, slow motion and fast scan display, some systems allow overlaying the video image with computer-generated text screens and graphics.

To explain the videodisc's varied information presentation and control capabilities, a classification scheme which defines "levels" of interactivity is widely used. A **Level I** system requires only a videodisc player, a television monitor and a control keypad, and has no "memory" or "processing power." It is, therefore, limited to linear play altered only by the basic **pause**, **search** and **stop** commands built into the player.

A **Level II** system is one in which the videodisc player has a built-in microprocessor with programmable memory. The control program is recorded on one of

the soundtracks of the videodisc and is loaded into the player's memory when the disc is used, a process commonly referred to as a "digital dump." Level II players allow for some branching and learner response-feedback cycles which are limited by the modest memory capacity of the typical Level II machine.

A **Level III** system employs a microcomputer with a videodisc player to provide significantly increased presentation and interaction capabilities. This combination allows for extensive branching and learner response analysis and for sophisticated information displays since computer-generated text and graphics can be superimposed over regular video images. The program required to provide this level of flexibility is stored on the computer's disk from which it is loaded into the computer's memory. Optional input or interface devices commonly used in Level III systems include keyboards, touchscreens, mouse units, light pens, and barcode readers.

A **Level IV** videodisc system embodies the major features of the other systems, but is distinctive in several critical respects. The control program is not stored on a computer disk, as in a Level III system, but is recorded on the laser disc itself, as with a Level II disc. But whereas Level II play involves "dumping" the control program into the player's memory, in Level IV, the program is downloaded into the separate computer's memory, making the system operable without need of the computer's disk. This simplifies program packaging and use since both subject matter content and control information are stored on a single disc. But it also means that the control program recorded on the videodisc cannot be modified, as one stored on a computer disk could be.

Digital Optical Disc Systems

Since 1982, when compact disc audio players were introduced, the term "CD" has become commonplace in the entertainment field. But continuing research and development has resulted in additional compact disc digital encoding formats suitable for instructional and information management applications. Among these, Compact Disc-Read Only Memory (CD-ROM), Compact Disc-Interactive (CD-I), and Digital Video Interactive (DVI) appear to be the most promising.

Although there are important differences in these three systems, they do share certain basic technical characteristics: all are reflective laser, optical disc systems; all are constant linear velocity (CLV) devices, and all use digital technology to encode information on the disc following the basic High Sierra standard format for data storage.

Compact Disc-Read Only Memory

This format, commonly called CD-ROM, was introduced in 1985 by Philips and Sony and follows the "Yellow Book" standard. Basically, it is a read-only, information storage and retrieval device that is commonly used as a computer peripheral. Because a CD-ROM disc can store over 600 megabytes of data--the equivalent of some 300,000 pages of typewritten text--it is obviously valuable for handling large databases and similar information collections. Most of the discs now on the market in fact contain large reference works; thus the format is commonly referred to as a "publishing medium."

In 1988 the basic "Yellow Book" standard was extended to include specifications for storing audio, pictures and graphics. Developed jointly by Philips, Sony and Microsoft, the new standard is called CD-ROM-XA (extended architecture) and its immediate benefit is to allow CD-ROM developers to enhance their products with audio and visual elements.

Compact Disc-Interactive

Compact Disc-Interactive (CD-I), a format that Philips and Sony announced in 1986, was designed to integrate audio, video and text on a single disc using digital technology and following the "Green Book" standard. The medium is intended both as a home information and entertainment system and as an education and training tool. Video is generated using video compression techniques and is displayed via a standard television monitor. Early systems, which were capable of displaying motion video on only a portion of the screen, were successfully demonstrated in 1988. In May, 1989, Philips announced that players with full-motion, full-screen video capability would become available in 1990 in both consumer and professional versions.

Digital Video Interactive

Digital Video Interactive (DVI) is a CD-based technology that was developed at the David Sarnoff Research Center (formerly RCA Laboratories) in Princeton, New Jersey. When first demonstrated in March, 1987, it was seen by many as a breakthrough in compact disc technology. Then the property of the General Electric Corporation, which had acquired RCA in 1986, DVI was later acquired from General Electric by Intel Corporation, a California based computer manufacturer that also develops advanced "chip" designs.

Like CD-I, DVI employs sophisticated digital encoding and video compression techniques in order to provide full-motion, full-screen video. But unlike CD-I, DVI uses the standard CD-ROM "Yellow Book" standard configuration. The video may include still images, motion images, graphics, text, or computer data and is displayed via the computer's display monitor.

Recordable Optical Disc Technology

Recordable optical disc systems have been developed in both the analog videodisc and digital compact disc technologies. Recordable analog videodisc technology is commonly referred to by the term Direct Read After Write, or DRAW, and its primary advantage is in enabling the user to record a playable videodisc quickly and inexpensively. A DRAW disc may be produced to serve as a "check disc" before a master disc is made, or it may serve some other purpose, such as training, where immediate playback is a necessity.

The recording process for a DRAW disc is similar to that used for producing a standard disc; however, the image quality of a DRAW disc normally does not match that of one duplicated from a master. The system's value lies in the real-time recording and continuous updating capabilities that it provides.

Recordable videodisc systems are available currently from three firms. Optical Disc Corporation's Recordable Laser Videodisc (RLV) model has been on the market since 1984 and is compatible with the LaserVision videodisc standard. The TEAC Corporation of America markets a desktop size, twelve inch videodisc recorder and a high resolution disc recorder in both monochrome and color models. A Teac player must be used to play discs made with these

systems. The Panasonic Optical Memory Disc Recorder (OMDR), is now offered in two disc sizes, the original eight inch and a twelve inch model. Playback requires an appropriate Panasonic player.

Many manufacturers now offer recordable optical disc drives that employ the digital technology associated with compact discs. Called WORM drives, for Write-Once Read-Many, they also enable the user to write on the disc as well as read from it. They are not erasable, however. These systems are mainly intended for text and data storage and retrieval, typically use a 5.25 inch disc, and are not compatible with the CD family.

Erasable Optical Disk Systems

Valuable as they are, "write once" recordable discs cannot be erased and updated and, therefore, their utility for maintaining files and databases is limited. Thus systems that employ erasable/rewritable disks are highly desirable for certain applications. Several units are available now and others are anticipated. Advanced Graphics Applications, a New York based firm, offered the first commercially available erasable optical unit in 1988 (Strukhoff, 1988, p. 24). It uses a 5.25 inch disk with 325 megabyte capacity per side and employs magneto-optical (MO) technology. Sony, Sharp and Kodak subsidiary Verbatim are among firms that also use MO technology in their erasable systems, and Canon USA produces a MO drive for use with the NeXT computer developed by Steve Jobs. Tandy Corporation has announced development of a system that employs "thermal optic technology" to allow creation and erasure of pits on a heat-sensitive layer of a CD format disc (Newsline, 1988, p. 3).

A third approach is known as crystalline-amorphous or phase change technology, which records digital information by heating extremely small areas of the disk's coating to change them from a crystalline to an amorphous state, a change that enables the disk to reflect a laser's light differently. Reportedly, both IBM and Matsushita have licensed this technology from its inventor, Energy Conversion Devices. Thus, as with the videodisc earlier, several different technologies will compete for the rewritable disk market in the future. All such systems employ digital technology and therefore are not substitutes for or upgrades of the analog

videodisc formats described earlier. Erasable and WORM drives, like the basic CD-ROM, likely will be used mainly as computer peripherals; however, their distinctive capabilities suggest that each will play a different role in information management. CD-ROM is widely regarded as a "publishing medium" whereas WORM and erasable units are expected to find wide application as "local storage" information systems.

Authoring Tools

The term **authoring tools** is widely used to refer to a variety of instructional design and programming aids in two general categories: **authoring languages** and **authoring systems**. An authoring language, as the name implies, is a computer programming language that has been designed specifically to issue the commands required in interactive lesson designs--commands related to visual display control, program sequencing and branching, student response assessment, and so on. An authoring system, on the other hand, is a software form that incorporates or "packages" a predetermined set of command functions and thus essentially eliminates the need for a designer to know language executed programming. The capabilities of available authoring systems vary greatly, but the basic idea is to provide the user with the necessary tools, e.g., templates, menus, prompts, to facilitate interactive lesson design. Authoring system prices also vary widely, ranging from less than $100 to over $5000. Consequently, selecting a system to meet an organization's needs requires careful analysis of features offered.

Hypermedia

There is now another software form which incorporates instructional authoring among its varied capabilities and, although, as a category, it lacks a commonly accepted name, it is rapidly gaining popularity among educators and developers. With brand names that include *HyperCard*, *SuperCard*, *LinkWay* and *Hyperties*, these multipurpose software "toolkits" are the basis for the growing number of "hypertext" documents and "hypermedia" programs being developed in educational settings. The hypermedia software packages appear to offer the user more versatility in handling information than authoring systems do, but may lack some specific features that certain instructional designs may require. Thus, for a given application, educational objectives and

learning strategies should guide selection of the appropriate authoring tool.

Integrated Optical Disc Systems

A basic videodisc player with its handheld control device is in many respects similar to other audiovisual media that have become commonplace in education. Realizing the full potential of the videodisc medium requires the creation of a complete system in which a videodisc player, a microcomputer, a display monitor and other components are assembled to provide a unit with the desired characteristics and capabilities.

The decision process in acquiring a complete system involves several issues. One is whether to assemble a system from varied components available in the marketplace or to purchase a ready-made "turnkey" or integrated system. Several manufacturers, Sony, Pioneer, IBM, NCR, Visage, Zenith, Matrox and Online Computer Systems among them, now offer complete system packages from which one can choose. A second issue is whether to choose an authoring/programming system first and match the hardware components to it, or do it the other way around. Underlying these decisions, of course, are considerations of the features and capabilities that are desired and, as always, cost. Some of the major features to be considered in selecting an optical disc system include information storage capabilities, multimedia presentation capabilities, audio capabilities, the user input mode, and the types and "level" of interaction desired.

Compatibility problems still arise between systems because of differences in computer hardware and in software needed to control video overlay circuitry and videodisc players. One way that large organizations can cope with the standardization problem was illustrated when the US Army issued its Electronic Information Delivery System (EIDS) specifications, and awarded a major contract for hardware systems to Matrox Electronics Systems of Canada. But while the volume of the Army's requirement for these units may make the EIDS specification a significant factor relative to technical standards in the field, the fact that this specification was not adopted by the other military services means that many competing and incompatible

systems will likely remain and share the civilian marketplace for some time to come.

There are indications presently that the IBM InfoWindow system is emerging as a "de facto hardware standard" (Magel, 1989, p. 51), including the fact that other firms, including Sony, Zenith and Visage, now offer units with "InfoWindow emulation capability." An interesting footnote to this development is IBM's recent announcement that its interactive videodisc system will now be called the InfoWindow Touch-Display while the term InfoWindow will be applied to all IBM PC-based display units.

But name changes are trivial concerns compared to continuing technological change--in computers, in optical disc media, and in authoring software. Choosing the ideal interactive technology system for a particular organization may be a difficult decision, but it most certainly is not an uninteresting one.

II. THE GROWTH OF INTERACTIVE TECHNOLOGY

The expanding role of interactive technology in education and training throughout the 1980's is, in large part, a function of increased use of optical disc systems, especially the videodisc. Various factors, both positive and negative, have affected the adoption and application of these media. On the plus side, these devices possess enormous information storage and management capabilities and are easily adapted to a variety of uses in education, medicine, publishing, database construction and other areas. Moreover, they are readily adaptable to information systems that vary widely in configuration, complexity and function. On the other hand, factors that have acted to slow adoption include equipment costs and system incompatibility. Also, videodisc program production is an exacting and expensive endeavor. Still, the application of optical disc systems to educational and other information management problems has grown steadily in recent years with many types of organizations contributing to this growth. This chapter presents a brief overview of that activity and identifies some of the interesting programs that have been developed.

Optical Disc Development: An Organizational Perspective

An assessment of organizational involvement with optical disc technology in the 1980's gives a strong impression that overall this is a well-based initiative from both educational and business perspectives. A sense of the effort's scale can be gained by reviewing briefly the participation of four organizational sectors--business and industry, government, educational institutions, and professional associations--with special emphasis on activity related to health professions education.

Business and Industrial Firms

Private organizations have contributed to the growth of the optical disc field in several ways. First, obviously, are the electronics firms that design, manufacture and market disc players, computers, and other devices that comprise optical disc systems. Many of these have been mentioned in the previous chapter. Second, there are now numerous firms that produce authoring systems and

other software to facilitate the design and control of instructional programs. Many firms in the training and human performance fields now offer interactive instructional design services, thus making optical disc program development a sizeable commercial enterprise. And, of course, there are those firms that offer optical disc mastering and pressing services, a small group that presently numbers about a half-dozen.

Two small firms that distribute information about optical disc technology and its application are Future Systems, Inc. of Falls Church, Virginia, which publishes the monthly Videodisc Monitor and markets other products, including books and software, and Stewart Publishing, Inc. of Alexandria, Virginia, which publishes the Interactive Healthcare Newsletter (formerly the Medical Disc Reporter) and an annual Medical Disc Directory. The 1989 edition lists nearly thirty private companies that produce or market videodiscs on healthcare subjects. Eleven different firms have produced at least four educational discs. Healthcare subjects for which substantial videodisc-based instruction is available include emergency medicine and critical care, orthopaedics, cardiology, ophthalmology, radiology, occupational health and safety, dentistry, and sexually transmitted diseases.

Government Participation

Public sector organizations have contributed to the growth of the optical disc field by becoming users of the technology and by supporting research and development activity. The US Army, by adopting the videodisc as a standard instructional delivery medium, and by issuing contracts for thousands of videodisc units, has given the technology a major boost, both in economic terms and in its credibility standing. The U.S. Air Force is also a major user of videodisc technology.

The U.S. Navy's activities are of more interest to health professions educators. The Naval Health Sciences Education and Training Command has launched a major effort to apply videodisc technology in health care training courses. One initiative, called CAMIS (Computer Assisted Medical Interactive-Video System), is a long term effort to place videodisc units in Navy schools and hospitals for continuing education and other training needs. An emergency medical program called

Combat Trauma and *MediQuiz*, which employs a game show format, are two of the best know programs.

Videodisc research and development has become a major interest of the National Institutes of Health, especially the National Institutes of Mental Health (NIMH) and the National Library of Medicine (NLM). They jointly developed a videodisc-based curriculum on teenage depression and suicide. The computer-controlled videodisc program presents several simulated cases of depressed adolescents to teach medical students and mental health professionals how to recognize and cope with the signs of suicidal depression. Initial testing was done in 1986 and a wider field testing program was completed in 1989.

In addition, the National Library of Medicine, through efforts within the Lister Hill National Center for Biomedical Communications, has been involved in several other videodisc projects. The Medical Pathology series, a basic pathology curriculum for medical students, was initiated in 1981, and now includes ten videodisc programs. Other projects have been undertaken in radiology and orthopaedic surgery. Technological Innovations in Medical Education (the TIME project), another NLM-supported effort, are videodisc-based, voice-driven "interactive dramas" which involve learners in simulated patient encounters.

Some state governments also have shown considerable interest in videodisc technology. The state of New Hampshire is seeking to make the technology widely available to local school districts through its "Videodisc Initiative" program. Florida is currently implementing an extensive effort to provide videodisc training to its corrections and probation officers. In this project, training materials originally recorded on videotape are being converted to disc format while newer courses are being designed for the chosen videodisc system.

These diverse government-sponsored videodisc projects illustrate that the technology affords a wide range of system configurations and supports varied educational applications.

Professional Associations and Consortia

Professional associations have been limited in their capacity and willingness to develop videodisc materials. Educational institutions traditionally have not been known for extensive participation in cooperative efforts to develop and share learning resources. Some recent events, however, indicate that the appeal and potential of videodisc technology may help spur such cooperative developmental efforts. Several groups have made noteworthy contributions to continuing education for health care professionals.

The American Heart Association, which Stewart (1987) says was "the first association to become involved in videodisc development for the health sciences," developed a disc-based system for teaching cardiopulmonary resuscitation (CPR) in 1981 (p. 6-1). The innovative system has an interactive mannequin which is wired with electronic sensors to monitor learner performance and provide corrective feedback. The program enables a user to receive certification in CPR without live instructor training, and is presently marketed by Actronics, Inc. of Pittsburgh, PA.

The American College of Radiology Institute in 1986 set out to produce educational videodiscs intended for both undergraduate students and practicing radiologists (Stewart, 1987, p. 6-5). The first program, called *Introduction to Ultrasound*, was produced by the Medical University of South Carolina and is no longer available from the ACRI. A continuing effort is underway to produce disc-based programs of the cases contained in the ACR Learning File. The pediatric section has been completed. The intent is to provide the programs in three formats: IBM compatible, Macintosh Hypercard, and Pioneer bar code (G. Pfaff, personal communication, September 29, 1989).

The American Academy of Orthopaedic Surgeons has collaborated with the National Library of Medicine to produce videodiscs for orthopaedic education. One disc contains a visual database of serial radiographs, arthrograms, and other images which can be viewed from different planes and at varying rates.

The National Board of Medical Examiners, as part of a long-term effort to administer its examinations by computer, has developed a computer-based examination

(CBX) of clinical competence that includes the use of a videodisc to simulate the presentation of patient findings.

Recent initiatives to form cooperative groups to promote videodisc use, particularly in health professions education, are a positive sign of the technology's appeal and of recognition by individual schools of the value of sharing resources. In mid-1987 a group representing some thirteen medical schools plus the US Army and US Navy met at the Uniformed Services University of the Health Sciences in Bethesda, Maryland, and formed the **Medical Interactive Video Consortium**. The group's objective is to promote adoption and use of videodisc technology in health professions education.

The Helene Fuld Health Trust established the Fuld Institute for Technology in Nursing Education (FITNE) in 1987 to promote the use of disc technology. The Institute produces and distributes interactive video programs for nursing education, provides information about hardware and software to its members and markets an integrated videodisc teaching system. It also has established a field testing network to determine the effectiveness of its videodisc programs and in 1988 selected 46 nursing schools to serve as test sites (D. Burke, personal communication, September 21, 1989).

Two quite different cooperative organizational ventures with similar objectives are the **Interactive HealthCare Consortium** and the **Healthcare Interactive Videodisc Consortium** (HCIVC). The Interactive Healthcare Consortium is described as "an educational publishing cooperative dedicated to the development and distribution of interactive videodisc courseware for the health sciences" (Stewart, 1988, pp. 4,5). Members of the consortium include various health science institutions, hospitals, private firms and others. Consortium members are able to share information, instructional programs, and other benefits. The consortium also acts as an agent to bring together schools and commercial firms with a common program development interest, and as a mechanism to channel proposals to potential funding agencies.

The HCIVC is a venture which IBM launched by soliciting proposals from health sciences schools that

wished to participate in a cooperative effort to develop and share courseware for use with the IBM InfoWindow system. The stated intent is to produce programs on broad topics that can meet various healthcare education needs, and to make the programs available at reasonable cost. Field testing of courseware by nonmember institutions is encouraged. HCIVC programs are generally available from the Health Sciences Consortium, Chapel Hill, North Carolina.

Educational Institution Initiatives

Universities and health professions institutions throughout the United States have played an important role in the development of interactive videodisc programs in various subject matter areas. Schools in the Southeast that have been active in videodisc development include Florida State University, which produced a program on *Human Genetics Training for Nurses* in 1982; Auburn University, where a prototype disc on heartsounds and, more recently, a *Cardiovascular Laboratory Simulation* disc were produced; The Medical University of South Carolina, which produced the *Introduction to Ultrasound* disc for the American College of Radiology Institute; The Medical College of Georgia, where a series of patient simulations have been developed; and the University of West Florida, which has established an **Office for Interactive Technology** and produced training videodiscs for the Florida Department of Health and Rehabilitative Services. The University of Kentucky College of Dentistry is reported to be developing two videodiscs on dentistry, one a tutorial and the other a demonstration ("Healthcare Application," 1989), and the Duke University Medical Center is producing several interactive programs in Physiology. Also, the Louisiana State University Medical Center is engaged in a project to develop two versions of an informed consent program on gastrointestinal procedures; one program is to be recorded on videodisc and the other is to employ a digital video and audio, still-frame presentation system (L. Bairnsfather, personal communication, January 16, 1990).

Among midwestern schools, the University of Iowa was one of the first to develop videodisc instruction for the health sciences. Two research discs were completed in 1982 and two others, *Assessment of Neuromotor*

Dysfunction in Infants and *Lamaze: The Nurse's Role* were developed for health professions education (Stewart, 1987, p. 3-11). The University of Nebraska initiated the **Nebraska Interactive Videodisc Science Instruction Project** which produced several college-level programs to provide laboratory experiment simulations. The University of Illinois at Chicago has produced an interactive videodisc called *Emergency Room Physician* and another titled *Back Stress and Body Alignment* while the University of Illinois College of Medicine at Urbana-Champaign has created a pathology information disc called the *Expandable Computerized Learning and Inquiry Into Pathology System* (ECLIPS).

Another videodisc, *Exploring Chemistry*, was also developed at the University of Illinois and it allows students to simulate chemical reactions. The University of Missouri at Columbia School of Medicine has developed a videodisc program which incorporates artificial intelligence features. Known as *AI/RHEUM*, the program teaches physicians diagnostic and treatment procedures for managing rheumatologic problems. Evaluation and further development have been carried on at the National Library of Medicine by original project team members now at that agency. Two Ohio institutions, the Case Western Reserve University School of Medicine and the University of Cincinnati Medical Center each have several healthcare related videodiscs under development.

In the Northeast, the Massachusetts Institute of Technology has become a leading center for experimentation in communication technology generally, and, in the videodisc area, has created a computer-assisted learning system in neuroanatomy which, through use of computer-generated graphics, affords students three-dimensional views of brain structure. The Yale University School of Medicine, in collaboration with the National Library of Medicine, has produced an echocardiology teaching videodisc. Cornell University Medical Center has created an interactive videodisc program on AIDS as part of a counseling and educational program. The Cornell Medical Center is also the site of the *PathMAC Lab*, a computer-based pathology teaching system which incorporated digital images.

The Dartmouth Medical Center has completed a program entitled *Choosing: Prostatectomy or Watchful Waiting*, which is intended to help patients to decide whether or not to undergo prostate surgery ("Projects Underway," 1989). This is the first of a proposed series of "informed consent" discs. Also in the East, the University of Maryland's Center for Instructional Development and Evaluation (CIDE) has for several years been active in videodisc program development for various clients, including the Naval Health Sciences Education and Training Command. This effort included a set of Anatomy and Physiology lessons for training Emergency Medical Technicians and another program to teach Medical Corpsmen response procedures for selected emergency medical conditions. And Bloomsburg University in Pennsylvania, using recordable videodisc technology, has produced several programs, some in conjunction with the Geisinger Medical Center. Titles include *Poison Prevention*, *MAST Trousers*, and *Crisis Management of the Ventilated Patient*.

Among Western institutions, the University of Washington has been especially active in videodisc development and is presently marketing several discs through its Health Sciences Center for Educational Resources. Most of these are so-called "generic" discs because they are mainly compilations of slide collections and other images and are designed to allow users to adapt the contents to individual instructional needs. The second version of the hematology disc (originally produced in 1982) and *Human Light Microscopic Anatomy*, an anatomy teaching disc done by Professor Frank D. Allan of the George Washington University Medical Center in cooperation with the National Library of Medicine, are perhaps the most interesting of the collection. The anatomy program includes a videodisc with over 2800 images, several computer disks that describe the images, and a search program to help build instructional lessons using the image resources. Also, through bar code access, the videodisc can be used as a supplement to a new anatomy text (Introduction to Functional Histology by Ira Telford and Charles Bridgman, Harper and Row, Publishers, 1990).

The University of Utah School of Medicine produced the widely-known *Slice of Life* generic disc which, in its most recent version, contains over 26,000 images to

support study in numerous medical areas, including pathology, histology, radiology and neuroanatomy. The University of Texas M.D. Anderson Cancer Center is developing several videodisc programs, for example, *Oncologic Emergency Management*, while the University of Texas Medical Branch School of Nursing is developing several others that address geriatric problems. Also, the University of Southern California's Annenberg School of Communications has developed an interactive program for chemotherapy patient education.

Numerous other examples of videodisc projects at health science institutions and universities in the United States and Canada could be mentioned. Those referred to here are intended to make the point that such projects are no longer rare and isolated activities. Schools serving the health professions that are **without** videodisc systems and programs are becoming the exception.

The Videodisc's Current Status: A Brief Assessment

It is now clear that videodisc technology has made varying inroads in business, education, the military and the health sciences. One way to gauge the technology's diffusion is simply to count the machines in use in various settings. The June, 1989, issue of *The Videodisc Monitor* reported that about 114,000 videodisc units were then in use for all applications surveyed. Interestingly, training and military applications accounted for over 51,000 units while education and health/medical uses totaled about 10,500 units. Based on these figures, it seems fair to conclude that the videodisc is becoming a major training medium in the military and in business and industry, but is still a relatively low-usage medium in health professions education, and, indeed, in education generally.

Another measure of the videodisc's status is the yearly dollar value of equipment sales and development costs. One estimate, attributed to Stuart Krasney of SK&A Research, Inc., places the 1987 industry total at $850 million. This estimate assumes sales of 53,000 hardware units at an average cost of $6,500 each, and development of 3,000 programs at an average cost of $150,000 (Lippke, 1987, p. 12). These figures provide at least a rough view of the industry's size, and the cost figures help explain why growth in educational applications has not been more rapid.

Many seem drawn by the videodisc's impressive capabilities and find a challenge in exploiting them for educational purposes. For these people, the videodisc is a vehicle of innovation. But others have remained "frozen at the wheel," as one observer put it, perhaps intimidated by the technology, confused about different formats and systems, worried about standards and compatibility concerns, or apprehensive about eventual costs and benefits. Thus it is not surprising that growth in videodisc application has been modest in educational settings.

But there are favorable signs, as well. Recently, a trade magazine serving the television field asked several "industry leaders" to identify events and trends that they considered to be significant plus factors for the spread of videodisc technology, (Lippke, 1987). Ithaca College professor Diane Gayeski listed several factors, including: "the development of flexible, easier to use, and more reliable authoring systems," the availability of programs that serve as "good examples," lower "mastering costs," and the widespread use of personal computers as control devices. She also expressed a belief that the "mystique" about using the videodisc is disappearing now that people are using it and reliable hardware is readily available (p. 15).

Other factors seen as encouraging are the growing quantities of "off-the-shelf" or "generic discs" and the growing involvement of major organizations such as IBM on the marketing side and the US Army and Navy on the user side. The Army is using the videodisc to meet many training needs and the Navy's CAMIS program (mentioned earlier) represents a broad effort in the medical field. Another positive factor is that continuing advances in electronics technology have led to generally lower prices for video equipment, microcomputers and other products which comprise interactive videodisc systems.

In sum, while the factors that inhibit videodisc adoption in education are not trivial, there are many hopeful signs. Reliable technology is available and the know-how required to use it, as well as the enthusiasm for using it, are growing. The educational need, of course, has always been there.

III. INTERACTIVE TECHNOLOGY APPLICATIONS

As the previous chapter illustrates, interest in applying optical disc systems and related technologies to education is widespread, though admittedly still limited. Health professions education is one area in which considerable progress has been made when progress is measured in terms of the number of institutions that are using the technology and the number of innovative or "prototype" programs that have been developed. This chapter describes several programs, mostly in the health sciences, that clearly qualify for that classification.

The imaginative design that many of these programs reflect is cause for optimism about the future place of the technology in education, particularly in the health sciences. Another encouraging factor is that the diverse range of applications illustrates optical disc technology's value and adaptability to widely varying levels of sophistication in information systems.

At a relatively simple level, optical disc systems have been employed as information storage and retrieval devices in which text material, numerical data, database entries or visual images are consolidated for easy access. In these applications, the system stores information that has traditionally been stored in other media forms and provides advantages of efficiency, economy and flexibility.

A second application level is reflected by the interactive videodisc used for instructional purposes, typically in the form of a tutorial, a simulation, a case study, or some combination of these formats. Creating such disc-based programs involves adapting the design-to-objectives instructional development model to the technological capabilities of microcomputer-controlled videodisc systems with the intent of improving learning efficiency and learner acceptance.

Using an optical disc system as a competency assessment instrument represents a third application level. A system that has been developed by the National Board of Medical Examiners to administer its examinations is one notable example of this technology.

A fourth optical disc application level is represented by the "expert system" which, under computer control, incorporates "knowledge representation" and "inference" mechanisms into the simulation that it presents or the problem that it addresses.

Finally, optical disc technology is also being applied in higher education and professional education settings as the basic storage medium in comprehensive institutional information management systems. The medical center appears to be an ideal candidate for this type of system because of its requirements for rapid, interactive access to very large data bases. At least one center has installed such a system and others may well follow.

The interactive systems described below exemplify these five functional or application levels and range from relatively simple to highly complex systems. They also illustrate the wide variety of program types that has emerged in response to different needs and problems within health professions education.

Information Storage and Retrieval Applications

Health scientists have always faced the problem of having convenient access to large quantities of information, especially visual images, for teaching and research. The optical videodisc, because of its enormous capacity for still-image storage, is being widely used to develop discs that serve as "image banks" or "picture lists" in different disciplines. Such discs typically do not embody a specific instructional design but serve as a resource for adaptation to varied uses in education. Thus they are often referred to as "generic" discs.

But even among such discs there are differences in technology and mode of use. For example, *The NLM Video Picture List* is a visual data-base comprised of pictures from the NLM History of Medicine collection that exercises program control and offers user interaction through the microprocessor that is built into the videodisc player, a "Level II" application. Another visual data-base developed at the National Library of Medicine uses barcode technology to select and access histology images from a videodisc that serves as a supplemental resource to a histology textbook, another "Level II" application. Both still and motion images are

available to the learner. The same videodisc is used as the image source for the *Microanatomy Video Library*, which exemplifies a more sophisticated "Level III" application in which a separate microcomputer provides access to the images stored on the disc. Many more visual data-base discs have been produced in recent years for use in varied health sciences disciplines.

Interactive Teaching Applications

The interactive instructional application of the videodisc represents a step up the ladder of functional complexity from the image library or generic disc, although the distinction is sometimes a bit fuzzy. One program that is described as both a teaching and image reference environment is *The Echocardiography Video-disc Encyclopedia*, which was developed cooperatively by Dr. Carl Jaffe of the Yale University School of Medicine and the National Library of Medicine. The disc contains a large collection of diagnostic images drawn from over 160 clinical cases. Animated graphics, text information and audible heart sounds are stored in digital format on a magnetic disk and user control and interface is accomplished through a Macintosh based hypermedia program. The system is designed to serve a wide audience ranging from medical students to experienced cardiologists.

Another hypermedia-based, visual teaching environment, the *PathMAC Lab*, has been created at Cornell University Medical Center under the direction of Dr. Daniel Alonso and Dr. Steven Erde. The system was developed using a Panasonic recordable videodisc player which was linked to a Macintosh computer to provide user access and control. The Panasonic disc can record up to 24,000 still-picture frames without using the conventional, and expensive, mastering process. Initially, about 6,000 images were recorded including photographs, microscopic views, X-rays and CT scans. The recordable technology, of course, allowed images to be added as desired. Each analog image has now been digitized and stored on a central file server. Eighteen workstations, placed in the pathology department and in dormitory locations, and the central file server were linked by Ethernet. This obviates the need for a disc player at each workstation. Consequently, this interactive system is no longer an optical disc environment. The digital system provides higher quality images and

simplifies updating which now can be done in a single location (S. Erde, personal communication, September 25, 1989).

A Level III videodisc called *An Introduction to Cardiovascular Examination* has been developed to teach the anatomy and physiology of the heart and auscultation of heart sounds. The program, developed by Mirror Systems and the C.V. Mosby Company, employs video sequences, computer graphics, animation and sound to illustrate cardiovascular processes. Recordings of actual heart patients were made and then digitized for synchronization with video animations of heart functions. Students can view physiological process sequences in any desired order or review them at will. The program also contains self-assessment exercises. In one sequence, for example, students are presented with a patient with abnormal heart sounds and are asked to characterize them. The program judges student performance and may recommend items for additional study. The system's main components are an IBM InfoWindow Touch Display unit, an IBM AT, XT or compatible computer, and an appropriate videodisc player.

Another innovative medical teaching development that successfully exploits both computer and videodisc capabilities is found in the electric cadaver concept. Two projects of this type are presently underway; one at Stanford University and the other at the University of Washington. The Stanford project, headed by Dr. Robert A. Chase and Dr. Steven J. Freedman and known as "*The Electric Cadaver*," is described as a "computer-driven, multimedia textbook" that serves as a "state-of-the-art video and computer graphics atlas of the human body" (Zagari, 1989, p. 783). While there are certain similarities between *The Electric Cadaver* and a book, the videodisc also contains photographic, radiographic, film and video material. The system is controlled by a Macintosh computer and Hypercard program written in Hypertalk, and uses two screens. In one segment, when an image that is accessed from the optical videodisc appears on the television screen, a corresponding digital image in outline form appears on the computer screen. When the image is rotated on the computer screen, using controls built into the program, the image on the video screen changes accordingly.

Certain types of clinical examinations also can be simulated using an "electronic probe." In short, while an electric cadaver is not a real one, it offers several advantages to the anatomy student--the capability for repeated electronic dissection being one of the most valuable.

The electronic cadaver project under development at the University of Washington has a similar goal--to make the study of anatomy available through a computer-controlled system. It is described as a database of 3-D images that serves as a model of the human body and allows users to view anatomical structures from many different angles (Jerome, 1989, p. 257). The database is composed of images of real cadaver parts that have been sectioned and recorded through photography and other means, including CAT scans and magnetic resonance imaging. The images are digitized for storage and manipulation in a system built around an IBM AT with a high resolution graphics card. Thus no optical disc storage in involved. Project director Dr. Cornelius Rosse explains the value of the system this way: "Students can assemble, disassemble and manipulate every part of the human body again and again, until they learn it" (Jerome, 1989, p. 257).

One of the most serious problems in medical education is providing realistic learning opportunities in patient management. Part of the problem is adequate access to patients and part relates to how to provide practice in clinical decision making without placing patients at risk. Increasingly, it appears, health professions educators are looking to videodisc-based simulations to solve these problems.

One such system that has been on the market since 1985 is known as *DxTER* and was developed by Dr. David Allan, a San Diego pediatrician. The system's main components are a videodisc player, an IBM PC family computer and an InfoWindow touch-screen monitor. Lessons have been developed in two series: Emergency Critical Care and Assessment and Intervention.

Each lesson presents a simulated medical problem, usually in the form of a drama that typically begins with a patient entering an emergency room with a critical problem which requires immediate medical attention.

The student, as attending physician, must prescribe a course of action to manage the care of the patient. Options are offered as a menu on the touch-screen and choices may include tests, further examinations, medications, or other actions. The program compels learners to make such choices while an on-screen clock records the elapsed time of the exercise. When a user makes a correct treatment choice, the patient improves; when an incorrect option is selected, however, the patient is shown to deteriorate. Each disc has several different endings which reflect possible results--from death to complete recovery--of the treatment regimen selected. Also, the program compares each user's treatment procedure with that recommended by a set of experts. Even the cost of treatment is recorded for comparison against an ideal estimate.

Intelligent Images, the firm which markets the DxTER simulator, reportedly intends to produce over 100 discs in critical care and other medical areas. As of 1988, twelve discs incorporating sixteen lessons had been completed and additional lessons are scheduled to become available in 1990.

The National Library of Medicine's Lister Hill National Center for Biomedical Communications was, from 1985 to 1988, the site for an advanced technology development utilizing voice recognition. The *Technological Innovations in Medical Education* (TIME) project, now affiliated with the Georgetown University School of Medicine, has resulted in three videodisc-based, interactive case study simulations: "The Case of Frank Hall," "The Case of Patricia Fletcher," and "The Case of Lucille Brandon." Their subjects, respectively, are alcoholism, obesity and geriatrics. All use the interactive drama format and, like other technology delivered simulations, all are intended to infuse more patient-centered learning into medical teaching. The voice-recognition technology that drives the programs, however, introduces new elements to their use in the classroom. Whereas most optical disc-based simulations are intended for individual student use, TIME dramas are intended to be used by faculty in group teaching situations. The individual instructor must "train" the system to recognize a set of control words, which are common terms used in medical analysis and patient management. The instructor then acts as spokesperson

for the class while students assume the role of attending physician. The interactive drama format is intended to provide both student and instructor the opportunity to engage in discovery learning since the outcomes of a learning episode depend on decisions made during participation and, therefore, are not predictable. The system components necessary to implement these programs include a PC-type computer, a videodisc player, a color monitor, and a Votan VPC-2000 voice recognition unit. The Frank Hall program disc consists of over 200 video scenes including diagnostic items, family history and documentation of his hospital stay. Using the voice-recognition facility to access desired scenes at will, the class can take a medical history, order diagnostic procedures, and make clinical decisions regarding treatment options.

Dr. William Harless, designer of the TIME case model, suggests that videodisc technology "has transformed the concept of computer-aided learning" and he sees the interactive drama as "a new educational format for classroom and small group teaching" (see Harless, 1986).

Optical Disc Technology in Competency Assessment Systems

Competency evaluation is seemingly a continuing problem in the professions, and Medicine presents a challenging example. For years the National Board of Medical Examiners (NBME) has been engaged in an effort with two major technological goals: to incorporate simulations into their examinations and to administer them by computer. The result is a system known as the Computer-Based Examination (CBX). It is intended to improve the administration of multiple choice questions as they are currently used and to enhance the assessment of clinical competence by employing videodisc-based clinical simulations.

To test patient-management skills, the user is presented with information regarding a "patient's" condition and complaints and is required to choose a patient management course. The situation is intended to mirror that of an actual practice condition. The physician has options regarding how to acquire additional information on the patient's condition and uses the computer keyboard to request information or tests and to administer selected treatments. Results of tests or

treatment procedures are presented on the computer screen to enable the physician to monitor progress.

The CBX system differs from many computer-managed simulations in one basic respect: test and treatment options are not cued by a menu or similar device. Users enter free-text requests for desired tests and therapies. As with most medical simulations, a CBX case simulates real-time relative to obtaining test results or seeing the patient respond to treatment. User performance is scored on both the adequacy of the tests and treatment procedures ordered and the avoidance of procedures that are unnecessary or involve undue risk (Piemme, 1988, p. 371).

The NBME is currently engaged in a continuing program to introduce and evaluate the CBX system at every medical school in the United States. The eventual goal is adoption of the CBX system for medical certification testing. Its use in that capacity is expected to enhance and standardize physician clinical competence assessment and to encourage wider adoption of computer-based simulation technology in education.

Expert System Applications

Optical discs have in some instances been applied as components of so-called "expert systems," that is, systems which embody "artificial intelligence" elements. When used in the context of instructional systems development, the term artificial intelligence has always been difficult to define. But two features in particular distinguish the "expert system" from the more common interactive video learning program: First, "they embody knowledge of a particular domain" and, second, they possess "inferencing mechanisms that enable them to use this knowledge in problem-solving situations" (Kingsland, Lindberg, and Sharp, 1986, p. 18). Thus the typical videodisc-based teaching program contains information that a learner may **access** to solve a problem whereas the information in an expert system represents a knowledge base that the system itself can **use** to assist in the problem solving endeavor. While an instructional videodisc may best be described in terms of the instructional strategy through which it engages the learner, the expert system is commonly described in terms of what it "knows" and how it "reasons."

One such expert system, called AI/RHEUM, was developed at the University of Missouri with the collaboration of Rutgers University computer scientists. Work began in the late 1970's and is continuing at the National Library of Medicine. AI/RHEUM is described as a knowledge-based consultant system in rheumatology with two major components: a diagnostic consultant system and a patient management consultant system. The system has been programmed to recognize twenty six different rheumatologic diseases and it performs its diagnostic reasoning by analyzing data supplied to it on up to 877 patient finding items. The reasoning process moves from patient data to "intermediate hypotheses" to the disease hypothesis by means of "production rules" that take the form of "IF...THEN" statements (Kingsland, Lindberg, and Sharp, 1986, p. 19). The system's diagnostic accuracy has been tested against that of Board-certified rheumatologists and in over 500 cases it has achieved over 90% agreement. A videodisc player, under computer control, provides the user with supporting visual material. Another support feature of the system is the ability to execute a MEDLINE search in which relevant findings from the literature are displayed on the computer screen.

Unified Information Management Systems

Computer-controlled interactive systems such as those described above are most commonly found in workstation environments intended for individualized study or information retrieval. However, they are now beginning to appear as elements of a more ambitious undertaking--the development of unified institutional information management systems. For example, several years ago, Ball State University of Muncie, Indiana, began planning efforts to establish "a new nervous system" for the university comprised of a campus-wide, fiber-optic network, a campus-owned PBX telephone system, and a master communication system for voice, data and video transmission (Steele and Metzger, 1988, p. 3). Under a project title of the "Teaching Environment Model of the Campus of the Future," the effort's stated goal was not merely to install new communications equipment but "to transform the university's learning environment into an information age learning laboratory" (Steele and Metzger, 1988, p. 4).

In the health sciences community, development of one such system is now in progress at the University of Pittsburgh, and the developmental plan spans the 1987 to 1992 period. The stated goal is to develop a medical archival system that will serve all institutions within the University Health Center and "provide access to a comprehensive biomedical database containing all of the patient and reference information needed in the course of clinical care, medical research, and education" (Vries, et al., 1988). Without such a system health care professionals will be unable to cope with the "information overload" that is found in both the general biomedical literature and in the body of clinical information that individual health care centers generate. A solution to this problem, experts at the University of Pittsburgh reasoned, could be fashioned using available technology. As a result of its "Campus of the Future" initiative, the University of Pittsburgh had a campus fiberoptic network in place that has been described as the largest in an academic environment. Optical disc systems now available have the capacity to store enormous amounts of textual data as well as the laboratory data and diagnostic images that a modern health care center generates. Modern microcomputers are sufficiently powerful to provide rapid access to needed information for many simultaneous users. Also, advances in artificial intelligence have facilitated natural language processing by computers.

The design of the system is geared to accomplishing three major functions: gathering, storing and distributing information. Information is gathered into the system through links to the hospital information systems within the University Health Center, to the Medical Records Office, and to individual diagnostic devices. Information, once gathered, is stored on optical discs as a "MARS-format database." This database operates on the premise that all data is either textual or text-associated in nature and, therefore, can be indexed, classified, stored and retrieved using bibliographic searching methods.

Information distribution is accomplished through a distributed, parallel-processing computer network that, functionally, is arranged in three layers. The "top layer" is the central data-processing unit in which a large multiprocessor capable of executing ten million

instructions per second (MIPS) provides overall database and network management. The "middle layer" consists of about 25 minicomputers, each functioning as a "local server" and servicing requests from 30 to 50 users. The "bottom layer" is comprised of microcomputer-equipped workstations that are distributed throughout the campus for end-user requests. Up to 1000 such workstations are envisioned for the system, giving it an aggregate capability of 1000 MIPS at a lower cost than that of an equivalent mainframe system.

It seems a safe prediction that in the medical center environment, the application of a unified information system to instructional purposes will follow closely its use for clinical care and research. The technical and logistical advantages are apparent. What's not so apparent are the effects that giving a university or professional school campus "a new nervous system" will have on teaching, learning and evaluation.

Concluding Observations

Some observations about the development and application of interactive technology in health professions education are obvious; others are much more speculative. It's obvious that the optical disc is a superb storage medium for text, visual images and graphics because of its great capacity and durability. It's also apparent that some very innovative instructional programs have been devised using computer-controlled, videodisc systems. Moreover, systems that facilitate competency assessment and disease diagnosis are in the experimental stage. What's not well known at present is how much, and in what ways, these systems will alter medical education practices in the future. The research that has been completed to date does not provide that information. Some of what it has provided, however, is examined in the next chapter.

IV. INTERACTIVE TECHNOLOGY RESEARCH

Conducting and interpreting research on instructional media has never been easy for educators and researchers. The usual problems of devising a rigorous research design and applying proper statistical analysis of data are often compounded by the difficulty of attributing any significant difference that might result. Was it really due to the medium's inherent effectiveness or to some uncontrolled aspect of the instructional treatment used? Consequently, the instructional research related to any communication medium is commonly subjected to two critical assessments: first, that many of the studies are not well designed and, second, that when a significant result is reported, it may in fact be a function not of the medium used but of some other variable, for example, a more rigorous lesson design. Interpretations of such research must therefore be made with caution. The research on interactive technology must be approached with extra caution for several reasons. First, the body of research is not large. Second, available studies are of several different types; some are intended to document how well the technology works, some compare one medium, e.g., interactive video, with another, and some focus on specific instructional design variables (Smith, 1987, p. 4). And third, there is no single definition of interactive technology that is shared by everyone in the field. The range of possible systems that current computer and optical disc technologies make possible is so wide that, as Bosco (1986, p. 15) argues, interactive video should not be regarded as a singular approach but as a "category designation" that includes many different approaches.

The following analysis of research on interactive technology is made with these reservations in mind, and is intended to provide at least partial answers to the following questions: What research has been done to document interactive technology's effectiveness? What findings have been reported? What do these findings indicate for instructional program design or application? What questions should future research address? The studies discussed below will include several related to

health professions education and others done in general education, or in military or industrial training settings.

Interactive Technology Research: Some General Observations

The literature on interactive technology includes descriptions of hardware systems and their specifications, descriptions of programs, reports of applications, discussions of design techniques, and research reports. Reports describing individual studies are not always easy to obtain, but several published review articles have provided valuable insights into the work that has been done. These include reviews by Kearsley and Frost (1985), Bosco (1986), Smith (1987), and Slee (1989). Understandably, most of the research discussed in these reviews was conducted using the videodisc medium.

Kearsley and Frost (1985) described several "outstanding videodiscs" that had been created by 1985, including the Cardio-Pulmonary Resuscitation (CPR) learning system developed by David Hon for the American Heart Association. But most of the studies they cite were done in military or educational settings, and while they concede that few of the studies are methodologically rigorous, they conclude that "the available evidence suggests that videodisc is a highly effective medium across all types of educational and training applications" (p. 9).

Bosco's 1986 review reported results gleaned from 29 studies of interactive video use to that time. Of particular interest is the distribution of organizations in which the studies were conducted: sixteen in educational settings, ten in the military, and none in the health science fields. The research design typically involved a comparison of an experimental group which received the interactive video instruction and a control group which received the customary training. Of the 29 studies, sixteen authors presented a general conclusion regarding the general effectiveness of interactive video. Bosco (1986) reported that 13 of these 16 investigators concluded that interactive video was effective while only three concluded that it was not effective (p. 8).

Smith (1987) also provided brief reviews of a number of studies and, despite reservations about a lack of data in some reports and the diversity of purpose among the studies, concluded that "specific evidence for the

effectiveness and efficiency of interactive video is growing" (p. 4).

Slee's (1989) review examines only about a dozen studies but is interesting for its discussion of the important issues and alternative goals of research on interactive technology. Slee proposes that such research can be examined under four categories called behavioral issues, cognitive issues, affective issues and economics. Studies classified as "behavioral" in focus are mainly those which compare interactive video with some other medium in teaching the same task or content with relative effectiveness judged by scores on achievement tests. While such studies often show results favoring interactive video, Slee concludes that differences in content or instructional method that occur in the two treatments under comparison "may account for the seeming superiority of interactive video" (p. 2).

Studies classified as "cognitive" in orientation are intended to go beyond direct media comparisons to examine variables that affect the information processing that is essential to learning. These variables include such factors as the value of interactivity, practice, feedback and orienting activities in guiding learning. Also of concern are questions related to how to design instructional treatments for different types of learning, e.g., procedures, concepts, principles and problem solving.

Affective issues are often studied in conjunction with a particular learning experiment to gauge learner attitudes toward a new medium such as interactive video. Consequently, such studies usually report data on learner preference for one medium or another. The limited data available so far does indicate that interactive video instruction is well received when used.

Economic issues are largely a matter of cost-effectiveness. Interactive video instruction is expensive to develop and, for most types of institutions, acquiring needed equipment in quantity is also a problem. On the other hand, interactive video training may, in some instances, offer substantial savings in learning time and in instructional resources utilization. Thus the economic issue will likely remain an important concern in future research.

Some specific studies of interactive technology applications, both in the health sciences and in other areas, are discussed in the following sections. Again, the videodisc has been the principal subject of this research.

Videodisc Utilization In The Health Sciences

Current research on videodisc utilization trends in the health sciences is insufficient to provide a clear picture of the technology's present level of use, let alone its future potential. One national survey that was completed in December, 1986, does provide some useful insights (Singarella, Bader, & Ramagli, 1988). The investigators mailed surveys to several professional groups within the health sciences field to determine levels and types of videodisc utilization. Survey participants included directors of biomedical communications, academic health sciences library directors, teaching hospital administrators, and others engaged in medical education.

Among the survey's major findings is that less than half of all respondents (109 of 247) indicated that any form of interactive videodisc technology was available to them at their institution. Slightly more than half of those without access to videodisc technology, however, indicated an expectation that the technology would become available to them "in the next year or so." Forty per cent of respondents reported having begun development of a disc and nearly that many (36%) reported that videodisc software development was underway. Other data regarding equipment choices and program costs have been reported by the study's authors. A follow-up study is now underway.

Until more studies are completed, however, knowledge of videodisc utilization at schools of the health professions will remain inexact and projections of future use will remain risky. Successive studies will no doubt report that increased numbers of health sciences professionals have gained access to the technology. Concern with access, however, must not preempt concern with attitude, and a conclusion stated by Singarella, Bader, & Ramagli (1988) is both instructive and disquieting in this regard: "It appears that the administration of academic health science institutions often does not understand what is needed for the effective development of interactive videodisc

technology" (p. 7). Arguably, correcting this condition is as vital to the future of videodisc technology as mastering the technology itself.

Interactive Technology Research in Health Professions Education

Evidence for the effectiveness of particular interactive learning programs is being developed through two efforts: controlled experimental studies and the testing of programs before their release and application. Some of the evidence for the effectiveness of interactive instruction in the health sciences, most of which is on videodisc, is presented below.

The Cardio-Pulmonary Resuscitation (CPR) disc-based learning system that David Hon developed for the American Heart Association has been described by Kearsley and Frost (1985, p. 7) as "perhaps the most intriguing instructional videodisc to date." In an early test of the system, Hon compared the performance of two groups of fifty students each, one that took the CPR course from a live instructor while the other used the videodisc system. The reported result was that three times as many students from the videodisc-trained group passed as did from the instructor-trained group. In addition, Kearsley and Frost report, "all videodisc students took less time than any of the students in the regular class" (p. 9).

A study conducted at the US Army's Academy of Health Sciences provides another example of using the videodisc to teach a medical procedure (Ebner, Manning, Brooks, Mahoney, Lippert, and Balson, 1984). The research team selected a lesson on the administration of an intramuscular injection, a task that is part of the school's medical specialist course and which was time-consuming and difficult to teach. A twenty five per cent failure rate was common. In the study, a control group of students took the normal training while the experimental group, after receiving the customary introduction, was given training with a level II videodisc that was produced by using elements of an existing videotape with programmed retrieval added. Trainees were required to take two proficiency tests after instruction and to register their attitudes toward the training. One result obtained was that the experimental group completed the training in a significantly shorter time period than did the group

receiving the conventional instruction. On the initial performance test, the authors report, 83 percent of the videodisc group passed as compared to 76 percent for the conventional group, a difference that was not statistically significant. However, on a second posttest given 17 days after training, 75 percent of videodisc trainees passed while only 59 percent of the control group students did (p. 28). The researchers also reported that on student critiques "videodisc subjects were significantly more complimentary about their learning experiences than were their control group counterparts" (p. 28).

Results of a later study completed on the same task were reported recently by Haynes (1989, pp. 68, 69). In this study, three groups were established: One received the traditional instructional method, a second received instructor-controlled videodisc-based training and the third was provided with student-controlled videodisc-based training. All groups received the same introduction, including a videotape overview of the task's procedural elements. The videodisc, again, included the visual information from the videotape and also incorporated programmed retrieval of segments that learners could review. No significant differences in effectiveness were obtained on either a posttest given two days after instruction or another given fifteen days after the experiment. Evidence that the videodisc training was more cost-effective was found, however; the student-controlled videodisc group took an average of ten minutes less than the traditionally taught group and the instructor-controlled videodisc group took, on average, forty eight minutes less. Also, students taught by videodisc registered a significantly higher level of "satisfaction" than did those who received traditional instruction. Because the videodisc provided time savings with no loss in student achievement, it was thought to be "potentially a more efficient method of instruction" for this "sophisticated psychomotor task" (Haynes, 1989, p. 69).

Haynes (1989, pp. 71-72) describes another example in which interactive videodisc was used to address a specific teaching problem in the health professions--detecting motor development dysfunction in infants. At the University of Iowa, the Department of Pediatrics and the Weeg Computing Center cooperated to produce

a computer-based videodisc program called *Assessment of Neuromotor Dysfunction in Infants*. The disc included basic information on motor activities and assessments on 27 infants. It was tested over the course of a year with third year medical students as they progressed through their pediatric clerkship. Four sets of experimental and control groups resulted and student learning was tested for both knowledge and diagnostic skill acquisition. Statistically significant differences favoring the videodisc instruction were found in both skill categories. Also, students generally expressed positive attitudes toward videodisc instruction. Subsequently, the videodisc program was included in the University of Iowa's medical and physical therapy programs (Haynes, 1989, p. 72).

Interactive Video Research in Other Settings

Kearsley and Frost (1985) have observed that the U.S. Army had conducted the largest number of videodisc evaluation studies. Army sponsored studies have ranged widely in content. Studies conducted at the Army's Academy of Health Sciences have been mentioned above. Another study compared the effectiveness of a videodisc simulation with both computer-based and classroom training on maintenance procedures for a missile control system. Reportedly, the videodisc-trained group took half the time to solve repair problems (Kearsley and Frost, 1985, p. 8). In a study at the U.S. Army Signal Center, trainees using a videodisc simulation to learn satellite receiver maintenance reportedly mastered the skills in 25 per cent less time than a group that used the actual equipment (Kearsley and Frost, 1985, p. 8). In a very different competency area, officer leadership and counseling skills, videodisc-based training was found to be superior to both role playing and programmed text treatments.

Kearsley and Frost (1985, p. 9) also report that studies in the corporate training field have provided evidence of videodisc effectiveness in such diverse areas as product training, railway safety, and word processing.

Numerous videodisc evaluation studies have been completed in educational settings. An early study by Bunderson and others (cited in Kearsley and Frost, 1985, p. 8) found that a videodisc trained group in college biology achieved significantly higher test scores

in about thirty per cent less study time. Other areas in which superior results for videodisc instruction at the college level include economics and test-taking skills (Kearsley and Frost, 1985, p. 8).

Studies such as those just described illustrate that interactive video is often a more effective medium of instruction than some other medium or mode against which it is compared. Often, too, it is more cost-effective when learner and instructor time is taken into consideration. And when learner preferences are surveyed, interactive video usually receives high marks compared to whatever has served as the "conventional" approach in a particular setting. Because such comparison studies address natural administrative concerns within organizations, quite likely there will be more of them. But scholars have noted that they are of limited value in explaining **why** a given instructional program is either successful or unsuccessful. Without such knowledge, it is recognized, there is little basis for specifying the design attributes that provide effective instruction generally. Consequently, various researchers (e.g., Slee, 1989) have called for more research on "cognitive issues" in order to identify specific design features which activate the mental processes necessary for various types of learning.

A few studies of this type have been completed, but not always with consistent results. Since learner participation is a major element of interactive instruction, the effect of practice events for different types of learning has been investigated in several studies. For example, Hannafin and Colamaio used interactive video in such a study and found that practice contributed to learning declarative knowledge and problem solving skills but did not significantly affect the learning of procedural knowledge (cited in Slee, 1989, p. 4). In another study, Phillips, Hannafin and Tripp (1988) examined the combined effects of orienting activities and various levels of practice. Orienting activities have long been thought to be valuable aids to directing student attention but these researchers, finding that such activities accounted for minimal score variance, concluded that "other, more powerful instructional variables simply subsume the orienting activity effects" (p. 101). Also, they conclude, that although practice is a dominating instructional variable

in interactive video, the "embedded practice questions" used in this study did not produce the anticipated level of effects (p. 100).

Other similar studies could be mentioned, as well, but the inference is clearly that much more research on design factors related to interactive instruction is needed. Bearing that in mind, it is useful to review some of the guidelines that various experts in the field have proposed.

Design Factors for Interactive Media

Research with interactive media has usually taken one of two forms: studies that seek to determine the effectiveness of the medium in delivering a particular program of instruction and studies that seek to determine the ingredients that make a program effective. As has been observed, one form is intended to prove a medium, the other is intended to improve the medium. Most of the research done on interactive video in the last ten years appears to focus on the question of the general effectiveness of the medium compared to "traditional instruction" or to some other media form. On the basis of such studies, most researchers appear to have concluded that the videodisc is an effective instructional medium in many types of educational or training applications settings. They also point out that generally the videodisc has been well accepted by those who use it and that often its use results in training time savings. But while the evidence supporting the effectiveness of interactive video is encouraging, it is certainly not overwhelming. Clearly, more research is needed to provide better understanding of the design factors that make interactive media effective. As Bosco (1986) has observed, with increasing use of interactive video, "there ought to be a growing sophistication about how to make it work and a clearer sense about the ingredients in successful applications" (p. 15).

It can be argued that the ingredient categories that comprise the recipe for successful interactive instruction are known, at least in name, but that it's the relative quantities and the mix of the ingredients that need further study. Thus a relatively small number of "design factors" can provide an umbrella under which future research needs can be addressed. These factors include

disc organization, interactivity features, visual design, learner participation, personality, and design metaphor (Kearsley and Frost, 1985).

The organization of a videodisc is, of course, quite different from that of traditional "linear" media forms. This raises questions about how various types of information will be organized on the disc and how access to different information elements will be facilitated. The intent is to make optimum use of disc space and to make it easy for users to "navigate" the disc while receiving instruction.

There is wide agreement that the fundamental design factor associated with the videodisc is interactivity and that the nature of the interaction in a given application is dependent upon the capabilities of the particular delivery system used (Kearsley and Frost, 1985, p. 9). These capabilities, of course, differ widely among the various "levels" of videodisc systems that were described earlier. Level III and level IV systems, which employ a separate microcomputer to control the system, provide more extensive and complex interaction possibilities than the less sophisticated systems do. But it should not be assumed that all instructional applications require highly complex branching options. Thus one fundamental research question relates to the optimum amount of interaction a program should offer; others relate to the type of branching mechanisms and feedback messages to be used.

Because the videodisc is a highly visual medium, the elements of visual design are of major importance. The quality of visual images is a basic concern, but one that is more a function of production technique than of design. Visual design questions relate to how to organize information on the screen, how much information to present on one screen, and how to combine video and computer-generated images for maximum effect.

It has become axiomatic that learners should be actively engaged in videodisc instruction and that they should be able to control the pace and sequencing of the learning process. There are two faces to the concept of active engagement. The menus, questions and other response eliciting features of a lesson require participation by the

learner. But in a larger sense, the design strategies or metaphors that a program employs can affect the degree of learner involvement. Kearsley and Frost (1985) suggest that making the learner a character in a game or simulation is a good way to increase learner involvement. Programs which simulate a job setting have also proved popular and effective in teaching problem solving and decision making. Surrogate travel represents an involvement strategy that was developed expressly to capitalize on the unique capabilities of optical disc technology.

Another design factor that is thought to have considerable influence on learner attitudes is what Kearsley and Frost (1985) refer to as a disc's "personality." Through a combination of all its features taken collectively, each disc creates a learning environment that learners perceive as being rigid and authoritarian, on the one hand, or more relaxed and supportive, on the other. The affective responses that learners have toward a delivery system can be expected to affect the amount of learning that takes place.

Conclusion

The interactive technology research base is, at present, not large. But neither is it insignificant; it has, arguably, provided three important outcomes.

One is implicit in Bosco's (1986) assertion that interactive video should not be regarded as a singular approach but as "a category designation for a wide array of approaches" (p. 15). This observation is significant for two reasons: first, it makes clear that a study that measures the effectiveness of a particular videodisc program cannot validly be generalized to interactive technology generally, and, second, it reinforces the argument that there is no scientific basis for additional studies that seek to compare "the videodisc" with another medium or with "conventional instruction."

The second outcome, and one that appears to find at least a modicum of redeeming value in the comparison studies that have been completed, is the verification that a number of highly effective teaching instruments have been developed in the videodisc format. In other words, if you do it right, an instructional videodisc is well worth the effort and expense.

The third significant outcome of the research effort with interactive technology is the growing realization that while summative evaluation is an important element in developing individual programs, we are not likely to learn **how** to do it right merely by analyzing gross effectiveness studies. In addition, research should investigate the effects of specific design variables within specific instructional models for specific types of learning. The brief overview of design factors presented above is indicative of the areas that merit study in such a research effort.

Finally, there is a another concern relevant to the ultimate success of interactive technology in health professions education that, it appears, has been largely overlooked in the research to date. This is the problem of applying interactive video in "real world" organizations. The quality of the instructional design is only one part of the equation; issues related to introducing new technology into an existing organizational structure and an existing curriculum delivery apparatus are also important (Bosco, 1986, p. 16). Thus their study is an essential component of a comprehensive research effort.

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Jerome, M. (1989, February). The electric cadaver. *PC/Computing*, pp. 257-258.

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Zagari, M. (1989). The electric cadaver. *JAMA*, *261*(5):781,783.

APPENDIX

Selected Information Sources on Interactive Technology

Associations

Association for the Development of Computer-Based Instructional Systems (ADCIS)
Miller Hall, Room 409
Western Washington University
Bellingham, Washington 98225

Association for Educational Communications and Technology (AECT)
1025 Vermont Avenue, N.W.
Suite 820
Washington, D.C. 20005

Health Sciences Communications Association (HeSCA)
6105 Lindell Blvd.
St. Louis, MO 63112

International Interactive Communications Society (IICS)
2298 Valerie Court
Campbell, CA 95008

Periodicals: Specific to Interactive Technology

CD-I News
Emerging Technologies Publications
LINK Resources Corporation
79 Fifth Avenue
New York, NY 10003

CD Publisher News
Meridian Data, Inc.
4450 Capitola Rd., Suite 101
Capitola, CA 95010

Interact Journal
International Interactive Communications Society
2120 Steiner Street
San Francisco, CA 94115

Interactive Healthcare Newsletter
Stewart Publishing, Inc.
6471 Merritt Court
Alexandria, VA 22312

Journal of Computer Based Instruction
ADCIS, 409 Miller Hall
Western Washington University
Bellingham, WA 98225

Journal of Interactive Instruction Development
50 Culpeper Street
Warrenton, VA 22186

The Videodisc Monitor
Post Office Box 26
Falls Church, VA 22046

Periodicals: General Educational Technology

Educational Technology Magazine
720 Palisade Avenue
Englewood Cliffs, NJ 07632

Instruction Delivery Systems
50 Culpeper Street
Warrenton, VA 22186

Tech Trends
AECT
1025 Vermont Avenue, N.W.
Suite 820
Washington, D.C. 20005

T.H.E. Journal
Information Synergy Inc.
2626 S. Pullman
Santa Ana, CA 92705

Videography
Media Horizons, Inc.
50 West 23d Street
New York, NY 10010

Books

Ambron, S., and Hooper, K. (Eds.) (1988)
Interactive Multimedia
Microsoft Press
Redmond, WA 98073

Crowell, P. (1988)
Authoring Sytems
Future Systems, Inc.
P.O. Box 26
Falls Chruch, VA 22046

DeBloois, Michael L. (1982)
Videodisc/Microcomputer Courseware Design
Educational Technology Publications
720 Palisade Avenue
Englewood Cliffs, NJ 07632

DeBloois, Michael L. (1988)
Use and Effectiveness of Videodisc Training
Future Systems, Inc.
P.O. Box 26
Falls Church, VA 22046

Haynes, George R. (1989)
Opening Minds: The Evolution of Videodiscs and Interactive Learning
Kendall/Hunt Publishing Company
Dubuque, Iowa 52004

Iuppa, Nicholas (1984)
A Practical Guide to Interactive Video Design
Knowledge Industry Publications
701 Westchester Avenue
White Plains, NY 10604

Iuppa, Nicholas, and Anderson, Karl (1987)
Advanced Interactive Video Design
Knowledge Industry Publications
701 Westchester Avenue
White Plains, NY 10604

Lambert, Steve, and Sallis, Jane (Eds.) (1987)
CD-I and Interactive Videodisc Technology
Howard W. Sams & Co.
4300 W. 62d Street
Indianapolis, Indiana 46268

Schwartz, E. (1987)
The Educators' Handbook to Interactive Videodisc
Association for Educational Communications and Technology
1025 Vermont Avenue, N.W.
Suite 820
Washington, DC 20005

Schwier, Richard (1988)
Interactive Video
Educational Technology Publications
720 Palisade Avenue
Englewood Cliffs, NJ 07632

Souter, Gerald A. (1988)
The DISConnection: How to Interface Computers and Video
Knowledge Industry Publications, Inc.
White Plains, NY 10604

Industry Guides

The Complete Interactive Video Courseware Directory
Convergent Technologies Associates
97 Devonshire Drive
New Hyde Park, NY 11040

Videodiscs in Healthcare (1990)
Stewart Publishing, Inc.
6471 Merritt Court
Alexandria, VA 22312

Training Resource Organizations

Bloomsburg University, Bloomsburg, PA 17815
(Instructional Technology Degree Program)
(Interactive Video Workshops)
Contact: Dr. Harold Bailey

Nebraska Videodisc Design/Production Group
(Annual Symposium and Videodisc Workshop Series)
KUON-TV, University of Nebraska
Lincoln, NE 68501

Society for Applied Learning Technology (SALT)
(Conferences and Tutorial Sessions)
50 Culpeper Street
Warrenton, VA 22186

The Learning Center For Interactive Technology

Educational Technology Branch
Lister Hill National Center for Biomedical Communications

For information and tour appointments:

Write: Coordinator
The Learning Center for Interactive Technology
Lister Hill National Center for Biomedical Communications
National Library of Medicine
Bethesda, Maryland 20894

Phone: (301) 496-0508 General inquiries
(301) 480-3035 FAX
(301) 496-0807 TDD (Auto answer)

Electronic Mail: EasyLink, Telemail, MCI Mail -- TWX (710) 824-9615
AMANET Mailbox -- TLC.NLM
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